Reconstructing fluid chemistry from mineral-fluid partitioning using the lattice-strain model

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Fluids exert a key control on processes in the Earth, from plate tectonics to ore formation. In order to understand and model these processes, it is therefore essential to know the properties of the associated fluids. Such information can be derived from the chemistry of the fluids, which also provides clues about the nature of the host environment. Unfortunately, it is rarely possible to determine the composition of these fluids directly and in most cases this must be reconstructed from the mineralogical and metasomatic imprint of the fluid on its host rock. However, at present such reconstructions are largely limited to the major constituents of the fluid, whereas it is the trace constituents, which are generally the most indicative of processes and host environment.

Lattice-strain modeling of mineral-fluid partitioning offers a potentially powerful means for quantitatively evaluating fluid composition. When the partitioning of elements between fluids and minerals is known at representative conditions, the chemistry of a fluid can be reconstructed from the composition of coexisting minerals. This approach is particularly suited to reconstructing the trace element composition of fluids. Furthermore, it allows the evolution in fluid chemistry to be determined from minerals formed at progressively later stages in the paragenesis. We present here the results of well-constrained mineral-fluid partitioning experiments and use the systematic behaviour in partitioning, as described by the lattice-strain model, to interpolate and extrapolate these data to conditions and elements outside those of our experimental system.

Previous application of lattice-strain modeling to mineral-fluid partitioning has been ambiguous. Our experiments indicate that this is due to non-uniform element speciation in the fluid. When such effects are accounted for, or where speciation is uniform, the lattice-strain model provides an excellent description of mineral-fluid partitioning. Given the ubiquity of fluids in the Earth and their control on a range of processes, this approach will provide a valuable and widely applicable tool.

Fluid flow rates and sediment pore-fluid interactions at the Carlos Ribeiro mud volcano (Gulf of Cadiz)

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Extensive research over the last eight years in the Gulf of Cadiz (NE Atlantic) has revealed a large number of hydrocarbon-related fluid flow structures including more than 25 mud volcanoes (MVs). A high resolution geochemical data set was collected from the Carlos Ribeiro mud volcano (2200m; deep Portuguese margin) to study sediment pore-fluid interactions in MVs. Quantification of fluid flow rates and composition is valuable as MVs function as an important element source for deep-water ecosystems in these environments. Piston, gravity and mega cores were recovered from five sites located on a 380 m long transect from the apex of the MV to mudflow pathways southeast of the crater. Extracted pore-waters show a strong and continuous depletion in chloride (Cl) content with minimum values of 200 mM at the centre of the MV crater, suggesting a freshwater source from below. Major cation concentrations indicate clay mineral dehydration as a possible source of low salinity fluids. High total alkalinity and hydrogensulfide concentrations are present in the near surface sediment which is commonly related to a chemosynthetic ecosystem driven by the anaerobic oxidation of methane. Smear slide observations revealed the presence of secondary processes such as dolomite and pyrite formation altering pore-water and sediment chemistry. Clay mineral data on mud breccia and clasts will be used to assess sources and diagenetic reactions within the Carlos Ribeiro MV. Applying a 1-D transport-reaction model to conservative pore-water constituents (chloride and boron), we estimate an upward fluid flow rate ranging from 14 cm yr^{-1} in the centre of the crater to 2 cm yr^{-1} on the periphery. The upper range of these fluid fluxes from Carlos Ribeiro MV is higher than most Gulf of Cadiz MVs, and similar to values estimated for Captain Arutyunov MV, identified as the most active MV in this area so far [1, 2].

[1] Hensen *et al.* (2007) *Geochim. Cosmochim. Acta* **71**, 1232-1248. [2] Niemen *et al.* (2006) *Geochim. Cosmochim. Acta* **70**, 5336-5355.